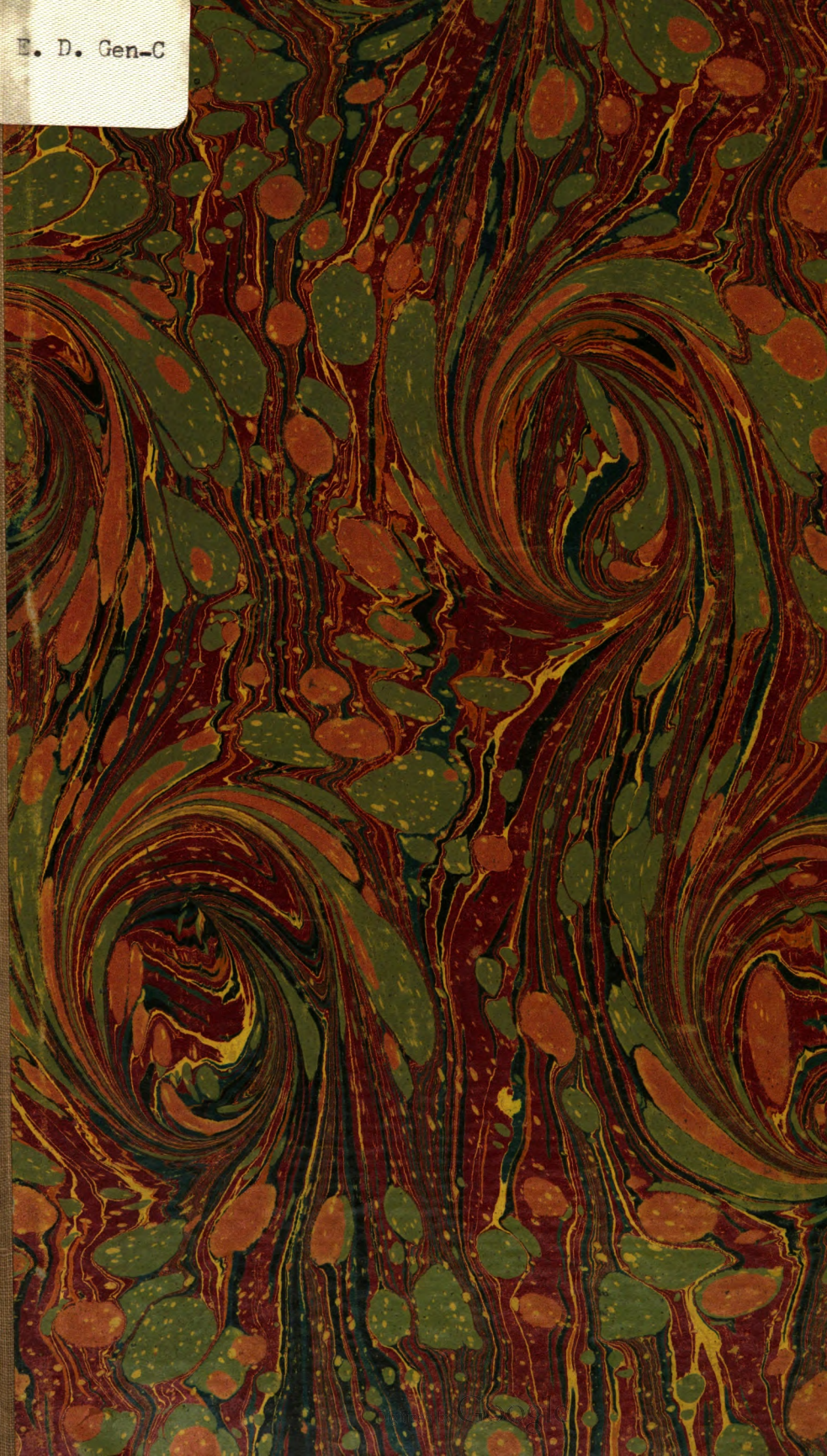


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NOTES ON ECONOMIC ENTOMOLOGY—No. 2.

THE
EXPERIMENTAL INTRODUCTION
OF
INSECTICIDES INTO INDIA
WITH A SHORT ACCOUNT OF
MODERN INSECTICIDES AND METHODS OF APPLYING THEM

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THE EXPERIMENTAL INTRODUCTION OF INSECTICIDES INTO INDIA.

Amongst means of combating insect pests insecticides hold a very prominent place.

A vast amount of laborious experiment has been carried out in America on this subject, with the result that certain preparations have been perfected and methods and apparatus for applying them invented. In fact the great advance which has been made within the last few years in methods of combating insect pests has been to a great extent because the Department of Agriculture in America has succeeded in bringing before the public cheap and effective insecticides.

The insect pests of India are believed to be almost without exception allied to American ones, in some cases being actually identical with them, and there is every reason to presume that insecticides which have been found valuable in America will be also applicable in India, though much may have to be done in experimenting on each particular Indian pest and in devising the cheapest and most effective method of utilizing the American insecticides upon it.

The cost of the labour of applying insecticides being a very considerable item in the expense of using them, India with its cheap labour is perhaps more favourably placed with regard to them than is America itself, where, however, it has been found worth while both to invent them and to widely make use of them.

A short account of insecticides and methods of applying them is appended to show concisely how the question at present stands.

A SHORT ACCOUNT OF MODERN INSECTICIDES, AND METHODS OF APPLYING THEM.*

Amongst a host of preparations, there are three chief and most generally applicable, which are being widely used in America and which are likely to prove useful in India.

They are—

- (1) Arsenical compounds.
- (2) Kerosene emulsions.
- (3) Pyrethrum.

The first act through the stomach, and are effectual chiefly against mandibular insects; the second and third act by contact, and are therefore of more general application, affecting both mandibular and haustellate species.

Fifty grains of arsenitate of soda and two hundred grains of dextrin dissolved in a gallon of water, and diluted at the rate of about an ounce to ten gallons of water, furnishes one of the cheapest of insecticides at command, and various patented combinations of it are said to have been extensively sold and used in America. Again, one pound of arsenic and one pound of sal-soda boiled in one gallon of water till the arsenic is dissolved, and diluted at the rate of one quart to forty gallons of water, is also a good formula.

The chief merits of arsenic are cheapness and solubility. Its chief demerits are its white colour, which makes it liable to be mistaken for harmless substances, and its tendency to burn the plants.

Paris green (or *Sheele's green*) is said to have been more extensively used than any other arsenical compound. Dr. Riley first recommended it in 1872 for the cotton-worm, and its use gradually extended to other leaf-eating insects, until hundreds of tons are said to have been sold for insecticide purposes in a single year in America. It is used dry with various diluents, as ashes, plaster, flour, &c., at the rate of one part of the green (if pure) to twenty-five, up to one hundred, parts of the diluent. Flour as a diluent has the advantage of causing greater adhesiveness and permanence. In liquid suspension *Paris green* can be used at the rate of one pound to from 40 to 100 gallons of water. The liquid should be kept constantly stirred, and a little dextrin or other substance, added to give adhesiveness, is an advantage.

London purple, a refuse obtained in the manufacture of aniline dyes, is probably one of the most important arsenical compounds. It consists of lime, arsenious acid, and carbonaceous matter, and was first

* Compiled chiefly from the reports of the United States Entomological Commission, much of it being taken *verbatim* from an address delivered by Dr. Riley before the Georgia State Agricultural Society at Savannah in February 1884.

used against the cotton-worm and other insects in 1878. It is used with diluents, either wet or dry, in the same manner as Paris green. While for some insects experience has shown it to be less satisfactory than Paris green, for many others it is equally effective, and has the great advantage over Paris green of being greatly cheaper (costing on an average but five cents against sixty cents per pound); of covering twice the ground, weight for weight; of being more soluble, less poisonous, more adhesive and permanent in its effects, and of decided colour, so that when intelligently used it is in all ways preferable.

Since the above was written in 1884 by Dr. Riley, the superiority of the London purple has been maintained, and it would appear to be the most generally useful of the arsenical compounds.

The following receipts, which have actually been used and found effective against various pests, are quoted as typical of the methods of applying arsenical compounds:—

- (a) Forty gallons of water, $\frac{1}{4}$ to $\frac{3}{4}$ of a pound of London purple (or $\frac{1}{4}$ to 1 pound of Paris green), three quarts of flour, the solid ingredients intimately mixed with the water by washing them through a strainer, sprayed upon the trees by means of a force pump and San José nozzle, was found to effectively destroy web-worm. The effect of the poison is sometimes not observable until after three or four days, care must therefore be taken not to overdo the spraying.
- (b) Bundles of cabbage, turnip leaves, or clover sprinkled with Paris green water and laid at intervals between rows, where cabbages have been sown, every three or four days, before the plants come up, attract and poison *cabbage cut-worms* before the crop to be protected appears above the ground.
- (c) One part of arsenic, one part of sugar, six parts of bran, mixed together with a little water and sprinkled over the fields, has been found effective in clearing plantations of locusts (*Melanoplus devastator*) in California.

In the case of vines (seven or eight feet apart), about one tea-spoonful of the mash is placed at the foot of each tree, which is then jarred to disturb the locusts. About ten pounds of the dry mixture is required for each acre, costing about 50 cents per acre, including the cost of application. This method of destroying locusts is chiefly applicable in orchards and gardens, where the insects are not very abundant.

- | | | | | |
|-----|---|-------|-------|-----------|
| (a) | United States Annual Report of the Entomologist for 1886. | | | |
| (b) | Ditto | ditto | ditto | for 1884. |
| (c) | Ditto | ditto | ditto | for 1885. |

Petroleum, in its various forms, has long been recognized as one of the most effective insecticides known, all oily substances being particularly deadly to insects. Unfortunately, they are also injurious to plants, and probably one of the most valuable works of the United States Entomological Commission has been the discovery of methods of diluting them so as to kill the insects without injury to the plants. Refined kerosine has been used to a limited extent, by forcible attenuation in water and spray, while some plants withstand doses of the pure oil. But the safe and general use of kerosine for the purpose under consideration dates from the year 1880. Of the various substances used in attempts to emulsify and mix kerosine with water, none are more satisfactory than soap and milk, both being everywhere accessible and cheap. An emulsion resembling butter can be produced in a few minutes by churning with a force-pump two parts of kerosine and one part of sour milk, or soap solution, in a pail; emulsions made with soap solutions being generally found to be the more effective. The liquids should be at about blood heat. This emulsion may be diluted with from nine to fifty parts of water which should be thoroughly mixed with one part of the emulsion.

The strength of the dilution must vary according to the nature of the insect to be dealt with, as well as to the nature of the plant; but, finely sprayed in twelve parts of the water to one of the emulsion, it will kill most insects without injury to the plant.

A reckless use of any penetrating oil upon plants cannot fail to prove detrimental. Kerosene is, however, much less injurious than the lighter oils, naphtha, benzine, &c., with which in a crude state it is associated. The refined oil, such as is commonly used for illuminating purposes, is safer, and should generally be used in preference to the lower grades, which contain a large admixture of other oils, which are said to be exceedingly deadly to vegetation. The spraying should be done by a force-pump through cyclone nozzles,—the essence of successful spraying consisting in forcing the wash in a fine mist, allowing as little as possible to fall to the ground, and permitting each spray particle to adhere. It is best done in the cool of the day, and where possible in calm and cloudy weather; two or three sprayings at intervals of a few weeks being far preferable to a single treatment.

The following receipts, which have actually been used and found effective against various insect pests, are given as typical of kerosene insecticides:—

- (a) Kerosene two gallons, common soap, or whale-oil soap, half a pound, water one gallon. The soap solution is added boiling hot to the kerosene, the mixture being churned by

(a) From Hubbard's Report on orange insects, dated 1885.

means of a force-pump and spray nozzle for five or ten minutes. The emulsion, if perfect, forms a cream which thickens on cooling, and should adhere without oiliness to the surface of the glass. Diluted before using, one part of emulsion to nine parts of cold water. This formula gives three gallons of emulsion, and makes when diluted 30 gallons of wash; it has been used very successfully against scale insects on orange trees in Florida.

- (b) Two parts of oil to one of soap solution or milk (the soap solution being made by dissolving from a quarter to one pound of common soap, or whale-oil soap, in one gallon of water). The whole is violently agitated at a temperature of about 100° F. by driving it backwards and forwards through a spray nozzle. The emulsion thus formed is diluted with nine parts of water. Flour or resin soap wash is sometimes added to the kerosine wash to give it greater adhesiveness; and four to six ounces of arsenous acid (or $\frac{1}{2}$ pound of arsenic, $\frac{1}{2}$ pound sal-soda, boiled in $\frac{1}{2}$ gallon of water till the arsenic is dissolved; or half a pound of London purple) is sometimes added to each 100 gallons of the wash to render it more effective. This was used successfully against *Icerya purchasi* scale in California.

- (c) Two or three ounces of flowers of sulphur added to each gallon of a wash (made as follows, kerosine two gallons, common or whale-oil soap half a pound, water one gallon) and applied in a fine spray is found to be the most effective combination against rust mite and scale insects on orange trees. It is best applied in early spring, and should never be used in mid-winter when there is danger from frost. The most effective sprayer for this purpose is found to be an aquapult pump and cyclone nozzles.

Pyrethrum cinerariaefolium, a plant native to Dalmatia, has long

been known to possess insecticide properties, especially in the powder from the dried and pulverized flowers. The species has proved to be hardy throughout the greater part of the United States, and Mr. Milco of Stockton, California, has for some years cultivated it extensively with considerable profit, the product being sold under the name of "Buhach." The insecticide properties reside in a volatile oil. It acts only by contact, and its action on many larvæ is said to be wonderful, a minute quantity in time paralyzing and ultimately killing. Its influence in the open air is evanescent,

(b) Taken from United States Annual Report of the Entomologist for 1886.

(c) Taken from Hubbard's Report on orange insects, dated 1885.

in which respect it is far inferior to the arsenical products; but being perfectly harmless to plants, it can frequently be used on vegetables where more poisonous substances would be dangerous.

Pyrethrum is supposed to have no effect on the higher animals. Dr. Riley's experience, however, is that fumes in a closed room have a toxic influence, intensifying sleep and inducing stupor; while the experience of Professor Bell, with the powder copiously rubbed on a dog, showed that the animal was made sick and was affected in the locomotive organs very much as is the case with insects.

The pulverized flowers are sold at about fifty cents per pound in America. The best method of using being to pour a quart of alcohol on a pound of the powder; leave it to stand for an hour and mix with forty or fifty gallons of water to be applied with a San José nozzle, or better to let the alcohol simply percolate through the powder and thus obtain a clear tincture, which can be applied with any nozzle. The powder may also be applied with bellows or mixed with water and applied by a pump.

Experiments will be made this year in growing the Pyrethrum in the botanical gardens of Seebpore and Saharunpore.

The following is an account of insecticides which are not so widely applicable as the preceding, but which nevertheless have been found useful against certain pests.

Other insecticides.

Bisulphide of Carbon still holds the first place in France against *Phylloxera vastatrix*; it is conveyed beneath the ground at the rate of half to one kilogram per vine, by special injectors, or by more complicated machinery drawn by horses. Dr. Riley believes, however, that kerosine emulsions will supersede it as an underground insecticide, and prove to be best, cheapness, safety, and efficiency considered.

Bisulphide of carbon is recommended* against the cabbage-fly (*Anthomyia brassicæ*), the maggot of which destroys the roots of cabbages and turnips. The bisulphide of carbon is used as for the grape phylloxera: a small hole is made in the earth near the main root of the plant, by forcing in a small stick, and about half a teaspoonful of the liquid is poured in, when the hole is quickly filled in with earth, which is pressed down with the foot. In every case where this was done the insects were killed without injury to the plants. In the use of bisulphide of carbon the extreme inflammability of its vapour must be remembered, and when much of it has to be used, a "Gastine injector," commonly used for the purpose in France, should be employed. As a safer and simpler remedy kerosine emulsion is recommended. Bisulphide of carbon has also been recommended for evaporation in shallow dishes on the top of grain stored in closed bins, for the destruction of the grain-moth (*Gelechia cerealella*). It has also been recommended by Professor Church for use against wheat-weevils.

* United States Annual Report of Entomologists for 1884.

Naphthaline and *sulpho-carbonate of potassium* are also of use against root-feeding or hypogean insects. Dr. Ernst Fischer has shown that naphthaline in crystal may be satisfactorily used underground, destroying by slow evaporation.

A wash made by allowing water to stand for several days in a shallow receptacle, in which a quantity of coal-tar mixed with a little oil-tar or oil of turpentine has been stirred until it becomes thoroughly impregnated with the odour, is found useful for washing cattle to protect them from the attack of buffalo-gnats (*Simulidæ*).

*A solution of *whale-oil soap*, one pound to ten gallons of water, is found useful against the rust mite on orange trees.

**Flowers of sulphur*, either dusted on the leaves or suspended in water and applied in spray, is also recommended as particularly fatal to rust mites on orange trees. A combination of whale-oil soap and flowers of sulphur is suggested.

Tobacco, tobacco water, and *tobacco smoke* have long been employed against aphides and other delicate insects, and are very useful. A recent advance is its use by vaporizing. The vapour of nicotine is most effectual in destroying insects wherever it can be confined, as in green-houses. Thus the boiling of tobacco in such green-houses is as effectual as the older method of syringing a decoction or fumigating by burning, while at the same time it is less injurious to the plants. The vapour gradually arising from tobacco stems strewn on the ground and regularly moistened has also been found to be effectual.

White helibore, either dry or in liquid, has been used satisfactorily against *Tenthredined* larvæ, otherwise known as "false caterpillars."

Soap, syringed in strong suds, will kill some soft-bodied plant-destroyers, and, when used as a paint on the trunks of trees, is an excellent repellant against the parents of various borers.

A mixture of one part of kerosine to three or four of castor-oil, linseed-oil, or whale-oil, thinly brushed all over the trunks and branches of fruit trees affected by apple scale in New Zealand, has been found by Mr. W. M. Maskell to be effective in destroying the pest without injury to the trees.†

A great many substances have at different times been recommended and tried with more or less satisfaction as insecticides. Of these may be mentioned lime, soot, salt, wood-ashes, corrosive sublimate, naphtha, turpentine, alum, carbolic acid, phenyle, cyanide of potassium, blue vitriol (sulphate of copper), hot water, &c. Most of these may be successfully used for specific purposes, either dry, in liquid, or in vapours, but none of them appear to be of any very general use.

* Hubbard's Report on orange insects, dated 1885.

† Scale Insects of New Zealand (Maskell), 1877, p. 33.

We have seen that the chief insecticides are applicable in liquids, and thus instruments for atomizing and distributing liquids constitute the most important part of insecticide machinery; what is wanted being a spray nozzle combining ready regulation of the volume to be thrown, greatest atomizing power, with least tendency to clog, facility of cleaning and ready separation of its component parts, cheapness, simplicity, and adjustability to any angle.

The nozzle which best combines these qualities is undoubtedly the eddy or cyclone nozzle, consisting of a small circular chamber with two flat sides, one of them screwed on so as to be readily removed. Its principal feature consists in the inlet through which the liquid is forced being bored tangentially through its wall, so as to cause a rapid whirling or centrifugal motion of the liquid, which issues in a funnel-shaped spray through the central outlet in the adjustable cap. The breadth or height, fineness or coarseness, of the spray, depends on certain details in the proportions of the parts, and specially in the central outlet.

To drive the liquid through the nozzle some kind of force-pump is required, and a great number have at different times been experimented with, some of them being of a most complicated nature. It is perhaps not of any very great consequence which particular form is adopted for use in India; but the aquapult force-pump, which has been arranged to be worked entirely by one man, who also distributes the spray, seems to be about the best suited for general use in a country where economy in labour is generally not so great an object as economy in the cost of apparatus.

EXPERIMENTAL INTRODUCTION.

The Indian Museum having now taken up the question of Economic Entomology, it would appear to be the most suitable centre for distributing insecticides, which have not as yet had a fair trial in India.

The following material might be procured for first experiments:—

1. A sufficient number of cyclone nozzles of various sizes and patterns for experiment with the different insecticides on pests affecting growing crops, which vary as to their nature and hence require individual treatment; also force-pumps, as recommended by the United States Entomological Commission.

The force-pumps and nozzles would be best imported direct from America, under the advice of the United States Entomologist, who might be asked to give his assistance in the matter.

2. A supply of Pyrethrum from the Buhach Producing and Manufacturing Company, Stockton, California, United States.

3. Supplies of white arsenic, Paris green, London purple, whale-oil soap, kerosene, naphthaline, bysulphide of carbon, and other insecticides, to be obtained locally when possible, otherwise from America.

Precise estimates of the cost of these materials cannot be at present provided, but probably three or four thousand rupees would go far towards obtaining all that are essential for a beginning.

A certain amount of initial expense is necessary to introduce the insecticides, and cover the cost of what is made over to persons capable and willing to conduct experiments and intelligently record the results. But when once the proper methods of applying the insecticides have been determined in the case of each pest, there is no reason why they should not be sold at such a price as to cover all expenses connected with them, and leave a margin of profit, as it may be confidently hoped that a considerable demand will spring up for insecticides when once their value is known.



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